SCIENCE

NEW SERIES
VOL. XLVI. No. 1178

FRIDAY, JULY 27, 1917

SINGLE COPIES, 15 CTS.
ANNUAL SUBSCRIPTION, $5.00

SCIENCE

Friday, July 27, 1917

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MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

ACIDOSIS[1]

I

For many years students of metabolism, of general physiology and of pathology have been investigating various aspects of the acid-base equilibrium of the body, always with an eye to the problem of acidosis, but at first with small success in unifying our knowledge of that complex subject. Successively it has been shown that in acidosis there may be a production of β-oxybutyric acid or some other specific defect of metabolism, an increase of the urinary ammonia, a diminution of the total carbonic acid of the blood, and of the blood's bicarbonate, an increase of its concentration in hydrogen ions, a diminution in the concentration of carbon dioxide in the alveolar air and of the free carbonic acid in the blood, an impairment of the affinity of the red corpuscles for oxygen, and a depletion of the alkali reserves of the body. Not all of these changes, however, are invariably present, and much confusion has resulted from the attempt to distinguish essential or primary phenomena.

At length it has become clear that acidosis is, from the standpoint of physical science, no simple and unitary state or process, but that, like metabolism or respiration, its unity is biological or functional, and that it consists in any disturbance, large enough and so long enduring as to be properly called pathological, of the regulation of alkalinity in the body. What are the disturbances to which this regulatory process is liable? They are such as are made possible by its normal and essential

[1] The Samuel D. Gross lecture, 1916.

peculiarities and general characteristics. These peculiarities can only be the object of special physiological investigations and the subject of special physiological knowledge. But in great part the more general characteristics are those of all organic regulations, and at this very point organic regulation is to-day best understood and analyzed. Accordingly, the description of acidosis must rest upon a clear definition of the nature of organization itself; it may then, in turn, help to define the larger problem.

This conclusion points straight back to Aristotle, whose great attainments as a zoologist together with his extreme virtuosity in conceiving and applying abstract ideas and formulas led him to an analysis of organization that remained the best for more than two thousand years. The words of Aristotle are as follows:

> The animal organism must be conceived after the similitude of a well-governed commonwealth. When order is once established in it there is no more need of a separate monarch to preside over each several task. The individuals each play their assigned part as it is ordered, and one thing follows another in its accustomed order. So in animals there is the same orderliness—nature taking the place of custom—and each part naturally doing his own work as nature has composed them. There is no need then of a soul in each part, but she resides in a kind of central governing place of the body, and the remaining parts live by continuity of natural structure, and play the parts Nature would have them play. ["De motu animalium," II., 703^a, 30–35, Oxford, 1912.]

This statement surpasses the efforts of the modern philosophers, who either have not understood the problem at all, or, like Leibnitz and Kant, have but imperfectly conceived it. The earlier modern biologists are also inferior to Aristotle, for when they have perceived the riddle of organization, it has led them into sterile vitalistic theories or mere bewilderment. But during the last century there took place a steady improvement in the biological analysis and lately the subject has been partly cleared of misunderstanding, so that it is to-day in the minds of most thoughtful investigators.

In the nineteenth century the concept of *organization* appears for the first time as an explicit postulate of scientific research. Of course there has never been a period when the idea of *function* was absent from physiological investigation. And it would be an almost hopeless task to trace the transformation of this idea, with widening experience, into the larger one of organization. Provisionally it may therefore suffice to note the conscious and deliberate use of the latter idea in Cuvier's so-called law. According to this hypothesis it is possible after a careful study of any one part of an animal, for example a tooth, to reconstruct the whole. Nothing could correspond more perfectly with Aristotle's original position concerning the organic relation between the parts and the whole.

Physiology was more deliberate in setting up the principle, because organic activity is harder to define and to describe. At least as early as the time of Johannes Müller the idea was clearly grasped. But not until the establishment of experimental morphology did it become overtly a guiding principle of physiological research. One very important influence toward this result is to be found in the speculations of von Baer.

The truly Aristotelian idea of internal teleology of the organism is at the bottom of von Baer's biological philosophy. Bichat and he are the first of the *organicists*. Their successor is Claude Bernard. This great man, whose purely mechanistic researches stand at the foundation of many departments of physiology, steadily exerted all his influence in favor of the idea of organization. He recognized a directive and organizing idea in the animal, and again and again insisted upon it. Yet his analysis of the problem, like that of von Baer, was not

complete. Though he, like all other physiologists, employed the idea of functional activity as a guide in research, though he was fully aware of Cuvier's method in paleontology, his just concern for the integrity of physiological method beguiled him into declaring that "the metaphysical evolutive force by which we may characterize life is useless in science, because, existing apart from physical forces, it can exercise no influence upon them."

This, strange to say, is an old error of Kant's. It is as if one should declare that the idea of the periodic system of the elements is useless to science, because, existing apart from the physical forces, it can exercise no influence upon them. What Claude Bernard well knew, but failed here to point out, is that organization, like the second law of thermodynamics, is a condition of those physio-chemical phenomena which were the subject of his investigations. At times, however, he stated the case more correctly.

During the later years of von Baer and Claude Bernard, the ideas of Darwin were accomplishing a revolution in general biology. Not the least important result was at least temporarily to establish adaptations as the most positive of realities. Yet an adaptation is only to be defined in terms of organization. In the orthodox Darwinian view it is that which contributes to the preservation of the whole. There is nothing in its merely physical character which enables us to recognize it as an adaptation. Only its function reveals its true nature.

In the course of time some of Darwin's original positions have been weakened and the more extreme views of his followers overthrown. As a result this manner of thinking about adaptation is somewhat out of fashion. But it endured quite long enough to leave its mark upon several departments of the science. And it is very doubtful if any one will be bold enough ever again to put aside the idea of function itself or to deny its necessary implications.

Meanwhile a number of independent lines of investigation have arisen from Darwin's researches. One of the most interesting of these is the study of experimental morphology to which Sachs gave an impetus. This subject appears to have developed, partly at least, as the realization of a program of research founded upon Roux's quasi-philosophical analysis of the characteristics of life.

Such a process is a genuine curiosity in the history of science. According to Roux the living being may be defined as a natural object which possesses nine characteristic autonomous activities, *e. g.*, autonomous excretion, autonomous ingestion, autonomous multiplication, autonomous transmission of hereditary characteristics, etc. This conception, as Roux admits, is closely related to Herbert Spencer's famous conception of life as "the continuous adjustment of internal relations to external relations." Roux's discussion of the subject was independent of Spencer's influence and, in its specification of conditions, his analysis possesses certain advantages over the English philosopher's more abstract statement. But, from the standpoint of physical science, it is gravely deficient in method and has never been regarded as more than a preliminary statement of the several physiological aspects of the fact of organization.

What has given Roux's investigation a certain value and influence is that there is thus presented, however dogmatically, a provisional discrimination of organic activities as a basis for the experimental physiological study of organization itself. With the foundation of experimental morphology the problem of organization assumes its proper place in physiological research. The experimental results of the new science clearly prove that the place is secure.

This department of science has developed independently, and only in recent years can its influence upon the older science of physiology be detected. The physiologists, in their more abstract and more analytical researches have usually dealt exclusively with physical and chemical phenomena. Unlike Roux's followers, they have been concerned with those things which are organized in the living being, rather than with the organization of them. Their very method of research, which proceeds from a preliminary analysis of the factors of organization, has obscured the larger biological problem.

At length Pavlov's researches on the glands of digestion, the study of internal secretions and hormones, Sherrington's investigation of the integrative action of the nervous system, Cannon's study of the emotions, and many other independent lines of investigation have cleared the ground, and at the present moment the physico-chemical treatment of the problem of organization is widely, if somewhat vaguely, recognized as the ultimate goal of physiological research. An interesting statement of the present condition of physiology in this respect may be found in Haldane's little book "Mechanism, Life and Personality." It is doubtful, however, if all the philosophical conclusions that Haldane draws can be regarded as well founded.

In the study of metabolism, which has also had an independent development, the idea of organization has long dominated research. This is due to the fact that here the concept of equilibrium can not be avoided. At an early period in the history of the science it was discovered that a normal organism is in a state of nitrogen equilibrium. That is to say, the composition, in respect of compounds of nitrogen, is steadily preserved, through the regulation of a long chain of intricate chemical processes. Day by day the ingestion of nitrogen is approximately equal to the excretion. A modification of the diet may cause a temporary disturbance of the condition, but this is soon restored. The phenomena of growth and disease are found to involve more enduring changes. Hereupon by a process of reasoning patterned upon that of physical science, growth is declared to involve nothing more than other phenomena superimposed upon the underlying conditions, thereby modifying the observed facts in such manner that the fundamental state is partly obscured. And disease is after all, in its very essence, a disturbance of organization; in short, diseases of metabolism involve by definition disturbances of equilibria, which may or may not be compensated.

Further research reveals similar equilibria concerning carbon, sulphur, phosphorus and the other elements. The results are extended to definite chemical compounds such as water, salt, sodium bicarbonate, glucose and the like. It is perceived that the equilibria of temperature, of volume, of alkalinity, which involve physico-chemical states, are truly analogous phenomena.

Meanwhile it has always been clear that within certain limits the existence of these equilibria is essential to the preservation of life itself, and that they might have been taken for granted. The real question has been to define the normal and pathological fluctuations, their duration, their limits and their relations to other phenomena. In short, so far as these problems are concerned, the study of metabolism has consisted in an attempt to describe as thoroughly as may be, and if possible to explain, the fluctuations of the approximately constant physical and chemical conditions of the body. In other words, the task of the investigator has been to make known the facts concerning the regulation of the ultimate physical and chemical constitution of

the organism. In this undertaking he has always kept in mind the idea that the organism exists in a state of dynamic equilibrium, just as it was long ago conceived by Cuvier, and more vaguely by Hume, and by Lucretius.

Now this idea of regulation, so familiar in the investigations of the temperature of the body, and in many other general problems of metabolism, is the very concept to which all the other independent investigations of organization as a physiological problem also lead. Thus Roux has long since declared, and recently reasserted the belief, that the capacity of autonomous regulation of all nine of his elementary characteristics is quite the most important of all the peculiarities of life. For example, he thinks that this is what makes possible the direct adaptation to the environment, or, in other words, the acquiring of characteristics. In like manner the action of hormones, the integrating function of the nervous system, and the phenomena of emotional excitement investigated by Cannon are all regulatory.

It is now possible to see that Herbert Spencer's conception of life as "the continuous adjustment of internal relations to external relations," though doubtless far from satisfactory as a characterization of life itself, is really a true statement of the phenomena of organization. Vague though it may be, it is confirmed by the results of experimental morphology, of physiology and of the science of metabolism, and I suspect that pathology affords some of the most striking justifications for such a view. Indeed pathology has its prerogatives, and of these not the least is to follow up the disturbances which, step by step, result from a single lesion or deranged activity until they close a vicious circle, to note the compensatory changes, regenerations and repairs that oppose this process, and thus to perceive the organism as a whole acting so as to preserve that state of dynamic equilibrium which is essential to life itself.

But Spencer's formula is at best imperfect and needs to be modified in order to conform more exactly to Aristotle's thought. Perhaps we may say that life is to be conceived as the continuous adjustment of internal relations to the state of the organism as a whole in accordance with changes of internal and external relations. Yet I can not believe that such formulas are of much account. What we need to know and always to remember is that organization qualifies the body mechanisms. They *are* mechanisms *and also* they are organized. It is in no sense a form of vitalism that is implied in this statement, nor can I think it, as Haldane believes, antimechanism. While I am in hearty agreement with many of Haldane's positions, I can not but repudiate this view. Yet a doctrine essential to all genuine biological progress does arise from this statement, and we are all indebted to Haldane for making it clear and insisting upon it. This doctrine teaches a very necessary truth concerning our present problem of acidosis, viz., that there is no one process or phenomenon which is the fundamental or essential one, but that each is integral, at once as cause and as effect in a cycle of pathological changes whose onset may be at any one of many points and which as a whole, as a cycle, constitutes the deranged acid-base metabolism. But this, moreover, is not the whole of the matter, for, just as the parts of this cycle engage in the whole of the process of acid-base metabolism, so do they also engage, as parts, in other processes, some of them in the respiration, some in the process of excretion, and so on indefinitely. Thus the condition known as acidosis can only be truly conceived in terms of the organization of the body as a whole. Such is the abstract nature of the subject; with this the known facts correspond.

II

From its very beginning, Arrhenius's theory of ionization emphasized the peculiar importance of the ions of hydrogen and hydroxyl. As products of the electrolytic dissociation of water these ions must be present in all aqueous liquids. As products of the dissociation of acids in one case and of bases in the other, they must be essential factors, or at least the only constant factors, of acidity and alkalinity in aqueous solutions.

Methods for the estimation of the concentration of these ions were presently found, and before long successfully, if rather roughly, applied to physiological problems. Thus it was proved that the reaction of blood is nearly neutral and very constant.

Meanwhile the theory was extended, with the help of the mass law, until it became a quantitative theory of acidity, neutrality and alkalinity. The principal results of this development of the subject, so far as they concern the biologists, are as follows:

First, the product of the concentrations of hydrogen and hydroxyl ions (at constant temperature) is approximately constant.

$$(\overset{+}{\mathrm{H}}) \cdot (\overset{-}{\mathrm{O}}\mathrm{H}) = c.$$

Therefore the concentrations of these two ions always vary inversely.

$$(\overset{+}{\mathrm{H}}) = \frac{c}{(\overset{-}{\mathrm{O}}\mathrm{H})}.$$

Secondly, if for convenience, just as the histologist uses microns instead of meters, we adopt as unit concentrations of hydrogen and hydroxyl ions a very small quantity, viz., the concentration of these ions in neutral solutions, the value of this constant becomes unity.

$$(\overset{+}{\mathrm{H}}) \cdot (\overset{-}{\mathrm{O}}\mathrm{H}) = 1,$$

$$(\overset{+}{\mathrm{H}}) = \frac{1}{(\underset{-}{\mathrm{O}}\mathrm{H})}.$$

It may be noted that, using this unit of concentration, an ordinary decinormal solution of hydrochloric acid has a concentration of hydrogen ions of nearly 1,000,000; and a decinormal solution of sodium hydroxide a corresponding concentration of hydroxyl ions. Other common dilute acid and alkaline solutions are only less remote from the concentrations of neutral solutions and of blood.

Thirdly, upon this basis the definitions of neutrality, acidity and alkalinity are as follows:

For neutrality,

$$(\overset{+}{\mathrm{H}}) = 1 = (\overset{-}{\mathrm{O}}\mathrm{H}).$$

For acidity,

$$(\overset{+}{\mathrm{H}}) > 1 > (\overset{-}{\mathrm{O}}\mathrm{H}).$$

For alkalinity,

$$(\overset{+}{\mathrm{H}}) < 1 < (\overset{-}{\mathrm{O}}\mathrm{H}).$$

Finally, in any solution containing a weak acid and its salts with one or more bases, regardless of the other components of the solution, the concentration of hydrogen ions is approximately proportional to the ratio of free acid to combined acid.

$$(\overset{+}{\mathrm{H}}) = k\,\frac{\mathrm{HA}}{\mathrm{BA}}.$$

This relation, however, holds only when the ratio of acid to salt is neither very large nor very small.

It is therefore evident that in the solution of any weak acid, when the quantities of free and combined acid are equal, the value of $(\overset{+}{\mathrm{H}})$ is k; if the ratio of acid to salt be 10:1, $(\overset{+}{\mathrm{H}})$ is 10 k, if the ratio be 1:10 $(\overset{+}{\mathrm{H}})$ is 0.1 k.

This is the total outcome of the theoretical analysis so far as it is necessary for a general understanding of the biological problem.

We may now turn to the special case of carbonic acid. For this substance the value of k, expressed in our present units, is about 5. Accordingly, in a solution of car-

bonic acid and bicarbonate, if the ratio of acid to salt be 10 the concentration of hydrogen ions must be 50, if the ratio be 1 the concentration will be 5, and if the ratio be 0.1 the concentration will be 0.5.

Thus we can see why carbonate solutions are almost always nearly neutral (*e. g.*, $100 > (\overset{+}{H}) > 0.01$), and, taking account of the universal distribution of free and combined carbonic acid in the ocean, in lakes and streams, and in all organisms, we understand the primary cause of the approximate neutrality of nearly all natural solutions, both organic and inorganic, upon the earth. In blood the concentration of hydrogen ions is about one third of the present unit, hence the ratio of free to combined carbonic acid must be less than 1:10.

In general it is evident that when the value of k for an acid is nearly 1 solutions containing that acid and its salts will be nearly always neutral; but that if the value of k differs largely from 1 such solutions will be nearly always appreciably acid or alkaline.

Beside carbonic acid, there is but one biologically common acid substance, viz., phosphoric acid after one hydrogen has been neutralized by base as in acid sodium phosphate, that possesses the value of k nearly equal to 1. Most weak acids have a value hundreds or thousands of times greater. Phosphate solutions are therefore commonly nearly neutral, and they share with carbonate solutions the function of preserving the constant alkalinity of the body.

It is easy roughly to demonstrate the general character of such acid-base equilibria with the help of the phosphates. Thus, for example, a solution of acid sodium phosphate has a faintly acid reaction, a solution of ordinary sodium phosphate an alkaline reaction, but almost any mixture of the two salts is neutral to ordinary indicators, and will take up strong acids or alkalis in large quantities without apparently changing its reaction. Of course every drop of acid or of alkali does change the reaction, but the change is so slight that it can not be detected by ordinary means. This depends upon the fact that strong acids and bases combine quantitatively with the alkaline or acid phosphate:

$$HCl + Na_2HPO_4 = NaCl + NaH_2PO_4,$$
$$NaOH + NaH_2PO_4 = Na_2HPO_4 + H_2O.$$

Accordingly, there is only a change in the ratio between the concentrations of the two phosphate salts, and of hydrogen ion concentration in due proportion, according to the analysis already given.

If the solution is supposed to contain bicarbonates, as well as phosphates, the above experiment fully illustrates the general character of the process by which acids are immediately neutralized in the body. The proteins, to be sure, are also involved, but their share in the process is small, though not physiologically insignificant.

Upon this physico-chemical basis the physiological processes are erected. It is as a means of restoring bicarbonate and alkaline phosphate from the products of reaction of these substances with acids, or as a means to neutralize acid, and thus prevent its reaction with bicarbonates and phosphates, that ammonia is produced in the metabolism.

In like manner the acidity of the urine is the result of the reversal in the kidney of the reaction by which acids have been neutralized in the body. In the renal function phosphates almost alone are concerned. Therefore the process may be described as follows: In the blood, as the result of the production of acid, a certain amount of alkaline phosphate has been converted into acid phosphate, so that the ratio of acid phosphate to alkaline phosphate has been

slightly increased. (Under normal circumstances this change is probably infinitesimal.) The kidney now removes relatively a still larger amount of acid than of alkaline phosphate, perhaps on account of changes in the blood bicarbonate rather than in the phosphate, and thus restores the ratio of base to acid in the blood. Here the essential factor is the ability of the kidney widely to vary the ratio of acid to alkaline phosphate without large variation of the hydrogen ion concentration of the urine. This very important fact once more depends upon the favorable value of k for acid phosphate.

It is because, in the normal individual, both the production of ammonia and the ratio of acid to alkaline phosphate in the urine are variable within wide limits, and can be made to conform exactly to the varying ingestion and production of acid in the body, that the fundamental physico-chemical apparatus can be kept intact and accurately adjusted.

A further factor in the process is the activity of the lung in excreting carbonic acid. This substance is the chief excretory product of the organism. As such it must be eliminated promptly and completely. Moreover, in that it leaves the body not in aqueous solution and as an acid, but almost exclusively in the form of gaseous carbon dioxide, there is no possibility of any variation of the permanent effect produced upon the reaction of the body by the elimination of a definite amount of it. In the final regulation by excretion it is not, therefore, concerned. And yet it has, in the process of excretion, a very important rôle in regulating the reaction of the body. This depends upon the fact that carbonic acid is not only a waste product, but also a normal constituent of the blood, and, as such, a principal factor in the physico-chemical regulation. Thus, if the ratio of carbonic acid to bicarbonates in a normal individual were 1:15, a large production of acid might cause a destruction of a third part of all the bicarbonates, producing in its place an equivalent amount of free carbonic acid. This, if nothing else occurred, would reduce the relative amount of bicarbonates from 15 to 10, and simultaneously increase the free carbonic acid from 1 to 6. The ratio would now be 6:10, and since the hydrogen ion concentration is porportional to this ratio, this ion would suffer a nearly ten-fold increase of concentration. But at this point, or, more strictly speaking, continuously during the process, the excretory function intervenes. There is a tendency for the respiratory process to hold the tension of carbonic dioxide in the blood nearly constant. This is the reason why carbonic acid has sometimes been thought the respiratory hormone. Assuming that the exact quantity of carbonic acid set free by the reaction of neutralization were thus eliminated, the ratio would be reduced to 1:10, and the hydrogen ion concentration would rise but one third above its original value. More recent investigations, however, have shown that a tendency to acidity is accompanied by a lowering of the tension of carbon dioxide. Let us suppose that in this case the tension was lowered one third. The free carbonic acid of the blood would then become 0.67 instead of 1.00, and the ratio of acid to salt 0.67:10, which is exactly equal to 1:15, the original ratio. Accordingly, the hydrogen ion concentration would be restored exactly to its original value, and the regulation by excretion would be quite perfect. Now there is abundant evidence to show that something very much like this is always occurring in the body, and, on the whole, I believe that the most delicate of all means to regulate the reaction of the body is to be found in

this variation of the tension of carbonic acid during its excretion. Such considerations have strengthened the hypothesis that the hydrogen ion is the true respiratory hormone. Originally suggested as a guess, this theory has been supported by many investigations. But I think that it marks the opening rather than the closing of a chapter in physiology, for the subject is involved in many complexities.

The whole physiological equilibrium may now be concisely summed up. The hydrogen ion concentration of the body has been seen to depend upon the ratio

$$\frac{H_2CO_3}{NaHCO_3}.$$

Acid reacting with this system causes a diminution of the denominator and an increase in the numerator of the fraction, the value of the fraction increases, and with it the hydrogen ion concentration. Hereupon the lung reduces the value of the numerator by diminishing the concentration of carbon dioxide in blood and alveolar air, the value of the fraction is restored more or less exactly to its original value and with it the concentration of the hydrogen ion. But the denominator is still below normal. To offset this, there occurs, on the one hand, a production of ammonia which takes the place in the urine of alkali existing as salt in the blood. This alkali recombines with carbonic acid, forming bicarbonate, and thus increasing the denominator. On the other hand, the kidney removes less alkali in combination with phosphates than exists in this state in the blood. This alkali, too, helps to regenerate sodium bicarbonate, and thus to increase the denominator. Both of these processes are so regulated that the denominator is restored to normal. The concentration of carbonic acid responds through the activity of the respiratory mechanism, and the organism returns to its normal state.

These processes, of course, go on simultaneously and not in succession. They are, moreover, far less simple than such an analysis admits, for on the one hand the interaction of phosphates and proteins has not been fully described, and, on the other hand, many of these variations influence other conditions and processes in the organism.

Among these effects are the influence of carbonic acid concentration and of the hydrogen ion on the affinity of hemoglobin for oxygen and on the volume of the red corpuscles. More general is a necessary, but at present indeterminate, effect on the distribution of electrolytes in the body, on the osmotic pressure, on the state of colloids, and on the volume. I fully believe that such effects are real and that when acid is produced through long periods and in large quantities in particular organs or tissues, as during diabetes, they may well surpass the direct effects of the simple chemical reactions of acid in the pathological complex, and produce a condition very different indeed from that of experimental acidosis. For in such conditions the whole physico-chemical composition of the cell, its concentrations and colloidal equilibria, might be sensibly altered.

But such guesses are one thing and the detailed and very dogmatic speculations of Dr. Martin Fischer quite another. And I feel obliged to say that there is not one particle of evidence for his conclusions, which are indeed inconsistent with, or totally without bearing upon, all the existing quantitative information that we possess upon this subject.

III

What then is acidosis? Evidently a condition lacking necessary connection with

the production of oxybutyric acid or with the magnitude of the hydrogen ion concentration in blood; still less a condition involving the existence of acid in the blood. It is often characterized by high urinary ammonia, but sometimes this quantity is low; the concentration of carbon dioxide in the alveolar air is commonly low, but one can not feel sure that this is invariably the case; in acidosis the oxygen capacity of the blood seems to be generally diminished, but we do not yet understand this subject well enough to be sure that compensatory changes may not take place. Upon the whole I think that we come nearest to certainty if we say that acidosis must involve a depletion of the body's alkali reserves, and specifically a depletion of the bicarbonate of the blood. So long as this has not taken place the pathological condition can not amount to much, so far as the acid-base equilibrium is concerned; when this defect is established the whole chain of causation, involving breathing, oxidation, nitrogen metabolism, renal activity and so on, has been set in motion.

The cause of the condition may vary widely. It may be due to the production of acid, or the ingestion of acid, or to lack of alkali in the food; it may be due to failure to eliminate acid, *e. g.*, acid phosphate, or to failure to produce and eliminate ammonia; but so far as can be seen it must always involve at least a diminution in the concentration of bicarbonate in the blood. As a practical maxim, we are therefore fully justified in saying that acidosis is a state of diminished bicarbonate in the blood.

Accordingly, it may also be said that the best means to the recognition of acidosis is proof of diminution in the bicarbonate of the blood. It is true that alveolar air, or the oxygen capacity of the blood, or the urinary ammonia, or the acidity of the urine, or the excretion of acetone bodies, may be definitive in any particular case. But a state of acidosis is certainly not always dependent on some of these variables, and may possibly be independent of all of them.

The most direct proof of diminution of the bicarbonate of the blood is afforded by an estimation of the capacity of the blood for carbon dioxide at a specified tension of the gas. This, or a related method, properly employed, will always give accurate information and need not make considerable demands upon the technical skill of the investigator.

But there is another method, consisting of a physiological test of the greatest simplicity and involving no experimental skill at all, which seems often to lead to equally trustworthy conclusions. The test depends upon an observation made by Sellards and also by Palmer and myself that in different pathological conditions and in different individuals the amount of soda administered by the mouth that is necessary to make the urine alkaline is a very variable quantity. Further extensive investigations of Dr. Palmer's have convinced me that this phenomenon depends on nothing but the retention of alkali by an organism whose store has been depleted, until the normal amount has been once more acquired. The addition of five or ten grams of soda to the food is enough to make the urine of a healthy person alkaline, and if more than that is retained, experience justifies the conclusion that a state of acidosis exists.

This test also points to a rational treatment of acidosis. For if sodium bicarbonate is administered at frequent intervals in quantities just sufficient to make the urine as alkaline as the blood, acidosis can not exist. The reaction of the urine can be followed closely enough even with litmus paper, a so-called amphoteric re-

action indicating that sufficient alkali has been provided, and if the reaction does not become more alkaline than this there seems to be no danger of injuring the kidney.

Of course this method may be inadequate to cope with the more complex problems of diabetic acidosis, and it is very doubtful if the alkali can always penetrate in sufficient quantities to the seat of acid production. There is, moreover, no reason to suppose that it can influence the cause of the condition. Indeed this is rather a matter of proper feeding than a therapeutic measure. For next to water and sodium chloride the concentration of sodium bicarbonate is the greatest in blood, and it seems not unreasonable to care for a sufficient supply of this substance as one does for a supply of water.

There is the more reason for bearing these conclusions in mind because acidosis is one of the commonest of pathological states. Indeed I think that it is probably more common than fever. Therefore one may conclude that in serious illness the test for acidosis should always be made, especially because it is often a very simple matter to repair the defect. And I think there is some reason to suppose that such action may occasionally be of the greatest importance.

But the use of alkali must always be deliberate and founded upon the urinary reaction, for too much alkali may be very harmful indeed. As employed by Martin Fischer in nephritis, experience has convinced me that it is a source of grave danger and, if possible, graver suffering to patients who can often expect from the physician little more than some relief from pain. Yet even in nephritis there is at present no reason to avoid the proper use of alkali. In fact, I have never known a kidney to be unable to excrete a small excess of it, and I think that we may therefore always undertake the administration of soda according to the rule above laid down, with the conviction that when the quantity of sodium bicarbonate in the body is below normal, no harm is to be expected from the action of sodium bicarbonate.

Finally, if I may be permitted to express as a precept my own conclusion of the bearing of all these intricate facts upon medical practise, it is as follows: The duty of the physician is to discover that the quantity of sodium bicarbonate in the blood is diminished, to restore that quantity to normal, and to hold it there. But while restoring it, he must never increase the quantity above normal. Thus founding practise upon exact knowledge, upon theory fully confirmed, and upon an understanding, however imperfect, of the organization of all the manifold processes of metabolism, he may hope sometimes to block a cycle of changes leading to final disintegration, and perhaps more often to alleviate discomfort and pain.

L. J. HENDERSON

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SCIENTIFIC EVENTS

THE IRON INDUSTRY

ABNORMAL conditions prevailed in the iron industry during the first half of 1917, mainly on account of the war in Europe. At the beginning of the year, when pig iron was being made at the average rate of about 102,000 gross tons daily, the blast furnaces were operated at slightly reduced capacity, according to E. F. Burchard, of the Geological Survey. This rate dropped to less than 95,000 tons daily in February, but in March the rate rose to 105,000 tons daily, and in April and May it stood at more than 110,000 tons, compared with the maximum rate of 113,000 tons in October, 1916.

The prospective blast-furnace capacity seems not to have kept pace with the demand, however, as is indicated by the enormous in-

creases in price, especially since the United States entered the war.

The total output of coke and anthracite pig iron in the first five months of 1917 was about 15,800,000 gross tons, compared with about 16,175,000 tons during the corresponding period of 1916, a decrease of about 2 per cent.

The quantity of iron ore from mines in the Lake Superior region shipped from upper Lake ports from January 1 to June 1, 1917, was about 6,500,000 gross tons, compared with slightly more than 10,100,000 tons for the corresponding five months of 1916, a decrease of about 3,600,000 tons, or more than 35 per cent. This apparently large decrease in ore shipments from the principal producing region was not due to inability to mine ore but largely to the belated opening of Lake traffic because of ice blockades and to many ore-carrying boats having been put out of commission through accidents.

Plans are being made by committees of the Council of National Defense to increase shipments of iron ore, coal and coke during the remainder of the season through cooperative methods, and possibly the June shipments will nearly equal those of June, 1916. In the meantime the blast furnaces have been drawing on large stocks of ore at lower Lake ports in order to offset the deficiency in upper Lake shipments. Deferred shipments of coke and other causes of traffic congestion have also retarded operations at some furnaces.

Prices of pig iron at western Pennsylvania furnaces have advanced since January 1, 1917, 61 to 77 per cent. and since a year ago 134 to 200 per cent. On July 3, 1917, basic iron was quoted at Valley furnaces at $52 a ton, Bessemer iron at Pittsburgh at $57.95, and No. 2 foundry iron at $55, while at Birmingham, Ala., foundry iron, which one year ago sold at $14 brought $47 a ton. Low-phosphorus iron has been quoted at $70 to $80 a ton. Feverish buying of pig iron by private consumers who were endeavoring to provide for their present needs, as well as for their needs far into 1918, has caused much of the recent increase in price. The extent of the government's war needs for steel is not yet defined, but increasing. Orders are being placed slowly, however, and they should not interfere seriously with deliveries of steel to private consumers. As the government is not competing in price it would seem that there may be at least some warrant for belief that prices may eventually adjust themselves without need for further great inflation.

METEOROLOGY AND AERONAUTICAL ENGINEERING[1]

Introductory: Importance of meteorology in aviation; aircraft and weather in war: (*a*) general climate; (*b*) weather and weather forecasts: military field meteorological services.

The Atmosphere: Composition; height; "troposphere" and "stratosphere": general characteristics of each.

Temperatures in the Free Air: Vertical temperature gradients; temperatures at various heights; inversions; stable and unstable conditions in relation to flying.

Pressure: Importance; comparison with water; decrease with altitude; physiological effects of diminished pressure; measurement; mercurial and aneroid barometers and barographs: use, errors, corrections; determination of altitudes by means of barometers; isobars; pressure gradients.

The Wind in Relation to Pressure at Earth's Surface: Wind direction; deflection of winds from gradient: earth's rotation and friction; cyclonic and anticyclonic wind systems; "gradient wind;" Buys Ballot's Law; isobaric types. Wind velocity; general relation to gradient; Beaufort Scale and its equivalents in force and in velocity in miles an hour; anemometers; Robinson and Dines; gustiness of wind.

Conditions of the Atmosphere Affecting Aviation: General and Local: (*a*) general air movements, essentially horizontal; atmospheric

[1] Syllabus of ten lectures on Meteorology given in the course in aeronautical engineering at the Massachusetts Institute of Technology in cooperation with Harvard University, by Robert De C. Ward, professor of climatology, Harvard University.

layers and waves; (*b*) local convectional currents, essentially vertical, due to thermal controls: causes and conditions; (*c*) effects of topography upon air movements, combining both horizontal and vertical elements, due to mechanical controls: effects of friction, topography, and character of surface; vertical and horizontal movements in general in relation to flight.

Weather Forecasting: Explanation of daily weather map; principles of forecasting explained by reference to type maps, for United States and for Europe; general characteristics of cyclones and anticyclones; tracks; velocities of progression.

Non-Instrumental Local Forecasts: Barometric tendency; veering and backing winds; changes in wind velocity; weather proverbs.

Clouds: Types; cloud classification; methods of determining cloud heights and velocities, and results; value as weather prognostics; fair and wet weather clouds; fog, special consideration of cumulus and cumulo-nimbus.

Forecasts of Wind Velocity and Direction Aloft: Direct observation by means of pilot balloons, kites and cloud movements; directions of cloud movements in cyclonic and anticyclonic systems in the United States and in Europe; estimates based on surface conditions and on general knowledge of upper air currents; "gradient wind;" diurnal variation in wind velocity and direction; changes due to progression of cyclones and anticyclones; wind and cloud directions and night flying.

Favorable and Unfavorable Weather for Flying: Wind; clouds; haze, etc.

Laboratory Work is given at Blue Hill Observatory (10 hours) by Alexander G. McAdie, Abbott Lawrence Rotch, professor of meteorology, Harvard University, and director of the Blue Hill Meteorological Observatory, Readville, Mass.

THE DANIEL GIRAUD ELLIOT MEDAL

AT a meeting of the council of the National Academy of Sciences, held June 19, 1916, the gift of Miss Margaret Henderson Elliot of $8,000 to establish a fund in memory of her father, Daniel Giraud Elliot, was accepted. This money was given to be held in trust and invested in order that there should be an income annually for a medal to be known as the Daniel Giraud Elliot Gold Medal, and an honorarium to be awarded by the National Academy of Sciences.

The conditions under which the gift is to be administered are contained in the following two paragraphs of the deed of gift:

One such medal and diploma shall be given in each year and they, with any unexpended balance of income for the year, shall be awarded by the said National Academy of Sciences to the author of such paper, essay or other work upon some branch of zoology or paleontology published during the year as in the opinion of the persons, or a majority of the persons, hereinafter appointed to be the judges in that regard, shall be the most meritorious and worthy of honor. The medal and diploma and surplus income shall not, however, for more than two years successively, be awarded for treatises upon any one branch of either of the sciences above mentioned. Professor Henry Fairfield Osborn, of New York, the scientific director of the American Museum of Natural History in New York City and the secretary of the Smithsonian Institute at Washington for the time being, are appointed as such judges. Vacancies at any time occurring in the number of the judges shall be filled by the council of the said National Academy of Sciences, and in each case of a vacancy it is the wish of the said Margaret Henderson Elliot that the council will, if practicable, appoint to the position an American naturalist eminent in zoology or paleontology.

As science is not national the medal and diploma and surplus income may be conferred upon naturalists of any country, and as men eminent in their respective lines of scientific research will act as judges, it is the wish of the said Margaret Henderson Elliot that no person acting as such judge shall be deemed on that account ineligible to receive this annual gift, and the medal, diploma and surplus income may in any year be awarded to any one of the judges, if, in the opinion of his associates, he shall, by reason of the excellence of any treatise published by him during the year, be entitled to receive them.

The council of the academy has accepted the gift and has appointed as the three judges for the bestowal of the medal and honorarium:

President Henry Fairfield Osborn, of The American Museum of Natural History.

Secretary Charles D. Walcott, of the Smithsonian

Institution of Washington.

Director Frederic A. Lucas, of The American Museum of Natural History.

The income from this gift to the academy will be sufficient to award the first medal and honorarium at the April meeting, 1918. Dr. Henry Fairfield Osborn has been designated by the president of the academy to act as chairman.

WESTERN AGRONOMIC WORKERS

The second annual meeting of western agronomic workers will be held at the Washington State Agricultural College, Pullman, Washington, and the University of Idaho, Moscow, Idaho (only nine miles apart), on July 31 and August 1 and 2, inclusive. The geographic scope of the gathering is the eleven western states occupying the territory from the Rocky Mountains to the Pacific Ocean.

The following topics will be discussed during the session:

1. Where and to what extent is it possible to eliminate summer fallow?
2. Rotation systems for irrigation sections.
3. Rotation systems for coast and intermediate sections.
4. Rotation systems for dry land.
5. Organic matter and nitrogen content of soil as affected by cropping systems.
6. Irrigation and alkali studies.
7. Methods and organization for supplying and distributing superior seed.
8. Possible extended use of new crops and the production of crops in the United States formerly supplied from other countries.
9. Cooperation among the states for investigating new problems.
10. The practical application of our investigations.
11. Better marketing, a factor for increasing food supply.
12. Collegiate courses in agronomy.

SCIENTIFIC NOTES AND NEWS

The Albert medal of the Royal Society of Arts for the current year has been awarded to Orville Wright, "in recognition of the value of the contributions of Wilbur and Orville Wright to the solution of the problem of mechanical flight." The report of the council says: "The largest share in the honor of having invented the aeroplane must always be given to the two brothers, Wilbur and Orville Wright."

M. Leclainche has been elected a member of the section of agriculture of the Paris Academy of Sciences, to succeed M. Chauveau.

Dr. William J. Mayo, of Rochester, Minn., has been summoned to Washington to confer with the government officials relative to the formation of a central medical staff in Washington, the purpose of which will be to obtain the best medical service for American soldiers while in the field.

Dewell Gann, Jr., of the medical department of the University of Arkansas, secretary of the Arkansas Academy of Sciences, has been commissioned a first lieutenant in the Officers' Reserve Corps, and expects assignment to a medical unit in France.

Mr. Barrington Moore, associate curator of woods and forestry in the American Museum of Natural History, has gone to France to give his services in a forestry regiment.

Professor Eliot Blackwelder, of the University of Illinois, is at present in California as a geological member of an advisory commission appointed by the governor of California to investigate the petroleum resources of the state.

Mr. Karl P. Schmidt, assistant in herpetology in the American Museum of Natural History, has been appointed a member of the New York State Food Commission.

The *Geographical Review* gives information concerning field work by botanists as follows: Professor F. E. Clements, who has accepted a position in the department of botanical research of the Carnegie Institution, is in the west and will devote the summer largely to grazing problems in connection with the national emergency. Incidentally he hopes to complete the task of securing material for a monograph he is planning to write on the bad lands. Dr. O. E. Jennings, of the Carnegie Museum of Pittsburgh, is spending the summer in botanical exploration and collecting

along the eastern shore of Lake Nipigon, the large lake in Ontario immediately north of Lake, some sixty miles distant. Mr. Thomas H. Lake, some sixty miles distant. Mr. Thomas H. Kearney, of the Bureau of Plant Industry of the U. S. Department of Agriculture, is planning in cooperation with Dr. H. L. Shantz, of the U. S. Department of Agriculture, the studies of native vegetation as an indicator of the agricultural capabilities of land in the western states which have been in progress during the past five or six years.

Professor Lawrence Martin, of the University of Wisconsin, gave instruction in topography at the Officers Training Camp, Fort Sheridan, Ill., during the last part of June and first part of July.

Dr. Hugh McGuigan, professor of pharmacology in the Northwestern University, recently delivered an address on "Blood Sugar in relation to Diabetes" before the faculty and students of the graduate summer quarter in medicine of the University of Illinois.

The first appointment to one of the new Logan fellowships at the University of Chicago has been made to Professor Walter George Sackett, of the Agricultural Experimental Station, Fort Collins, Colorado, for the academic year 1917–18. These fellowships were recently endowed by Mr. and Mrs. Frank G. Logan, of Chicago, for research in experimental medicine for the purpose of discovering new methods and means of preventing and curing disease.

The Council of the University of Leeds has conferred upon Colonel de Burgh Birch, C.B., late professor of physiology and dean of the faculty of medicine, the title of emeritus professor.

Sir Cooper Perry, physician at, and superintendent of, Guy's Hospital, has been elected to the office of vice-chancellor of the University of London for the year 1917–18, in succession to Sir Alfred Pearce Gould.

Sir Napier Shaw, director of the British Meteorological Office, has been appointed Halley lecturer for 1918, at Oxford.

The death is announced of H. Van Laer, professor of chemistry at Mons, and president of the Chemical Society of Belgium.

UNIVERSITY AND EDUCATIONAL NEWS

At the meeting of the board of regents of the University of Texas, held on July 12 and 13, President Vinson was continued as head of the institution, though without formal action to that effect on the part of the board. The following members of the faculty were dropped: Professors L. M. Keasbey, W. H. Mayes, W. T. Mather and A. Caswell Ellis, and the secretary of the university, John A. Lomax. Of these most had been previously mentioned as slated for dismissal by the governor, but Professor Keasbey was charged with disloyal utterances at the recent pacifist meeting in Chicago. The governor has not indicated any method by which the funds for the maintenance of the university may be secured, but the regents are making plans, on a restricted program, to have the institution open for work in the autumn.

We learn from *Nature* that the valuable collections of Arachnida, containing more than 1,000 types, with the library, notebooks, drawings and papers in connection therewith, bequeathed by the late Rev. O. Pickard-Cambridge, to the University of Oxford, have been deposited in the University Museum and placed in the charge of the Hope professor of zoology, Professor E. B. Poulton.

J. C. Bradley, of Cornell University, will spend next year as assistant professor of entomology at the University of California.

Fred W. Padgett, who for the past four years has been research fellow in oil, gas and gasoline in the University of Pittsburgh, has been appointed associate professor of chemistry in the University of Oklahoma, where he will have charge of developing a research department in oil, gas and gasoline.

Harry Clinton Gossard, assistant professor of mathematics in the University of Oklahoma, has been appointed to a mathematical position in the Naval Academy at Annapolis, Md.

Dr. Sam Farlow Trelease has been appointed assistant professor of plant physiology in the agricultural college of the University of the Philippines. He sailed on July 18 and begins his work on arriving at Los Baños.

DISCUSSION AND CORRESPONDENCE

MAN AND THE ANTHROPOIDS

In our current scientific literature one frequently meets the assertion that man is a lineal descendant of the anthropoid apes. The evident implication is that the extant anthropoids, orang, gibbon, gorilla and chimpanzee, are intended. Thus in the issue of "Science," of February 23 *ultimo,* Professor Stewart Paton remarks:

> The time is rapidly passing, as Yerkes has pointed out, when on account of the disappearance of the higher apes it will be possible to trace the various gradations in our ancestral line.

The correction of this common error lies all along the line of technical evolutionary thought from Huxley to the present, but it does not seem to have penetrated popular science. Our leading authority in this field, Professor Duckworth, in his "Morphology and Anthropology," Volume I, page 238, Second Edition, 1915, writes:

> We must conclude that the existing anthropoid apes, constituted as they now are, did not figure in the ancestral history of man.

This should relieve our anxieties regarding "our ancestral line."

While our knowledge of the anthropoids is not as complete as we might wish, the whole of it is against the supposition of the natives of the Congo and of Borneo that man is ascended from the anthropoids or the latter are descended from man. The thraldom of morphology accounts for much biological belief both ancient and modern, but the science of the present puts much more weight on anatomy and physiology. It appears to be a sound principle that groups showing inverse developments are not genetically related. Duckworth points out some of these inversions as regards man and the anthropoids, such as in dentition, in the spheno-ethmoidal angle, and in the spheno-maxillary angle. Metchnikoff, while he assumes as a hypothesis that man is descended from "some anthropoid ape," pointed out that the present anthropoids have the *os penis* which does not appear in man, and that the *hymen* which is unique to the *genus Homo* is absent in the anthropoids. Several anatomists have followed Aristotle in holding that the hand places man in a distinct order, while Topinard was equally emphatic regarding the human foot. Evidences along these lines are supplemented by pre-historic archeology, as all the older human crania are dolichocephalic, while the crania of all anthropoids are extremely brachycephalic.

Whether "scientists" are entitled to believe what they please or are to be guided by observations and verifications is perhaps an open question. Weismann accepted *generatio aequivoca,* although he admitted "all the evidence is against it." Still, many of us believe that a sound science and a sound education demand fidelity to the facts of experience and to those theories alone which grow out of them.

Mattoon M. Curtis
Cleveland

A GIRDLING OF BEAN STEMS CAUSED BY BACT. PHASEOLI

During a field trip in Michigan in July, 1914, the writer found a peculiar girdling of the stems and branches of field beans to be prevalent in several localities. Specimens were collected from Kent, Newaygo and Tuscola counties. Since then specimens of this disease have been collected from various parts of the state each year.

The disease appears at the nodes of stems and branches as small water-soaked spots. These enlarge, encircling the affected parts. Later these diseased areas become amber-colored. This girdling is usually completed by the time the pods are about half mature. The affected tissue is so weakened that from the weight of the tops the stem breaks at the diseased node. These signs of the disease may appear before any evidence of the bacterial blight upon the pods.

Inoculations into stem nodes of healthy plants, with a pure culture of *Bact. phaseoli* Erw. Sm. have produced typical signs of the disease. Plants so inoculated also showed the characteristic breaking at the stem node.

Plants inoculated in a similar manner with cultures of species of *Fusarium* and *Rhizoctonia* isolated from platings of this diseased stem tissue, showed no girdling or breaking.

It seems likely that infection results from the washing of bacteria from affected cotyledons or leaves to the axils of the leaves, but the method of entry of this organism is not yet worked out.

A more complete report upon this disease will be given at a later date.

J. H. MUNCIE
MICHIGAN AGRICULTURAL EXPERIMENT STATION

QUOTATIONS

SCIENCE AND INDUSTRY

THE important and impressive review of the rise and progress of the organic chemical industry issued by Messrs. Levinstein, Ltd., of Blackley, near Manchester, and of Ellesmere Port, which appeared as a supplement to the *Manchester Guardian* of June 30, marks a welcome development of industrial enterprise. Even the most indifferent and ill-informed reader can not but be made aware, as a result of its perusal, of the importance of the highest facilities for scientific education and training, when in so striking a fashion he is compelled to realize the fruits of it in the enormous industrial advance of Germany in all that pertains to the organic chemical industries, whether it takes the form of artificial dyestuffs, synthetic organic products, or that of chemico-therapeutics. The advent of the war quickly laid bare our serious deficiencies, not to say our utter poverty, in all three departments of chemical manufacture.

In the course of the articles, which have been written by men eminent in their respective fields of chemical science and its applications, the distinction is made absolutely clear as between industries the development of which has mainly been the result of the adoption of steam power and of mechanical appliances, and those depending upon fundamental researches of a physical and chemical character, such as are, to use the phrase of one of the writers, "built up from the depths," and require, therefore, not merely the energetic business organizer and "scientific management," with a view to output, but the highly trained scientific man capable of appreciating the discoveries of pure science and apt in their application to human needs. In this valuable review of the progress of the many departments of a vital industry—the key, indeed, to the successful prosecution of many allied and dependent industries—it is clearly revealed how remiss the nation has been in a true appreciation of what constitutes the firm foundation of industrial preeminence. The fault has lain not so much, as some of the writers seem to indicate, with the colleges and universities as with the industries concerned, which have hitherto offered small salaries and poor prospects to the carefully trained and competent science student; indeed, have looked upon the chemist as a necessary evil, to be avoided if possible.

One of the most important articles is that by Dr. Levinstein, inasmuch as he carefully points out the respective spheres of the university and the works in the effective training of the future industrial chemist. Once those concerned with the successful administration of our industries realize the necessity for encouraging by a liberal payment the work of the efficiently trained chemist there will be no lack in the supply of suitable men. That the nation contains such men has been shown by the fact that the demands of this devastating war for the supply of high explosives have been met with an energy and an efficiency which have surprised our chief enemy.—*Nature.*

SCIENTIFIC BOOKS

The Theory of Measurements. By LUCIUS TUTTLE, B.A., M.D., Philadelphia, Dr. Lucius Tuttle, Jefferson Medical College. 1916. Pp. xiv + 303. Price $1.25.

Any one who has read the reports on elemen-

tary laboratory work in physics presented by average students must have been impressed frequently by the writer's lack of familiarity with ordinary methods of computation and by his inability to draw rational conclusions regarding the accuracy and significance of his results. Unfortunately, the instruction in these matters presented by many widely used laboratory manuals is very inadequate and frequently misleading. We all admit that the primary object of elementary laboratory work is to put the student in personal touch with the facts and principles of physical science. But every experienced teacher knows that this object is not attainable without more or less formal instruction in the methods of reduction and interpretation of observations. Moreover, the student is seriously handicapped by the longhand arithmetical processes taught in secondary schools when greater precision and facility can be attained by the shortened methods of computation adopted by every competent physicist.

A number of books designed to fill this gap by a detailed discussion of methods of computation and the theory of errors have appeared during the past few years. Dr. Tuttle's "Theory of Measurements" belongs in this group and it meets the needs of students in elementary physics more adequately than any other text that has come to the reviewer's attention. For the most part, concrete examples are developed to illustrate general principles and the discussions are so clear and well stated that the student can hardly fail to grasp their significance. The treatment presupposes no training in mathematics beyond that usually required for admission to college. In fact capable high-school pupils should find little difficulty in following the discussions.

The most important topics treated in the first one hundred pages of the book are as follows: fundamental ideas, abridged methods of multiplication and division, units and measurements, angles and circular functions, accuracy and the correct use of significant figures, logarithms, computations involving small magnitudes, and the use of the slide rule. The reviewer would be inclined to place more emphasis on the importance of systematic orderliness in computation and exact specification of units in writing numerical results. But on the whole the treatment is very good and guards against most of the common errors of inexperienced computers.

About seventy pages are devoted to a very illuminating discussion of the methods of graphical representation and reduction of observations, including a brief treatment of interpolation and extrapolation. The possibility of emphasizing the significance of the plotted data by a suitable choice of scales is illustrated by numerical examples and the advantages of so choosing the variables that the graph will be linear are pointed out. The uses of logarithmic and semi-logarithmic papers are also illustrated.

The remaining portion of the book deals with errors of observation and measurement, statistical methods, the determination of the best representative value from a series of discordant observations, the estimation of the precision of direct and indirect measurements, and simple applications of the method of least squares. The formulæ of the theory of errors are not derived mathematically but their significance and use are very clearly explained and illustrated by numerical examples.

The book is neatly printed and substantially bound. It should find a place in every physical laboratory devoted to the instruction of students.

A. DEFOREST PALMER

SPECIAL ARTICLES

LITHOLOGIC EVIDENCE OF CLIMATIC PULSATIONS

THE geologic evidences of changes of climate, as is well known, are numerous and incontrovertible, particularly as regards extremes of temperature and their accompanying variations of flora and fauna. The climatic changes which have produced the most widespread changes in life forms, as well as physiographic features, have been the ones most clearly recognized and easily studied. These changes are known to have been pulsatory or periodic, but with periods or cycles

enduring for possibly many thousands of years.

In modern times, and in very recent geologic times as well, there have been minor fluctuations or pulsations in climate in various parts of the earth, as ably demonstrated by Brückner, Huntington and others. The "Brückner cycle," about thirty-five years in length, illustrates one type of pulsation. Hann, Melldrum, Douglass, and others have observed an eleven-year period to be about the average length of time between the maxima of wet or dry conditions. While the length of the cycles or periods may vary, the combinations of these shorter cycles of climatic changes are considered as making up the grand or climatic cycles, which are the ones best known in geology.

If the pulsatory theory of climatic change is a true interpretation of the observed facts of recent times, as seems very probable, then one may naturally inquire if similar pulsations or minor changes in climate have not occurred in the geologic past. If they have, what evidence, if any, is to be found in the rocks? The work of Barrell, Sayles, Case and others, in their studies of sedimentation, seems to definitely correlate climatic fluctuations with various phases of erosion and deposition. It may be of interest to submit some facts which may prove to be additional evidence of climatic pulsations, as afforded by certain "sedimentary" rocks.

The writer, in the course of a study of the sandstone formations in the foothills southwest of Fort Collins, in northern Colorado, came to the conclusion that much of this sandstone is of subaerial, and not subaqueous, origin. The sandstones of this region are commonly referred to as "Red Beds." The stratigraphic names are the Lyons, and the Lykins formations.

In the most prominent ridge of the Lykins outcrop are located a number of quarries from which flagging and building stone have been taken for many years. One prominent feature of much of this stone is its variegated laminations. These are usually alternate layers of white and brown sands, although other colors are occasionally found. These layers vary in thickness from about 0.5 mm. to 30 or 40 mm. In a number of cases the white layers are much thicker than the brown, while in many other cases the two kinds of layers are nearly equal in thickness. Also, the brown layers are often thicker than the white. Very thin alternate layers often occur, and there are usually many of these in a group when they do occur.

Examination of the character of typical samples from these layers shows, essentially, the following facts:

1. The white layers are composed almost wholly of very well rounded grains of white quartz, with scattered specks of iron oxide; the quartz grains are nearly uniform in size, the largest being rarely over 1 mm. in diameter, and the smallest about 0.3 mm. in diameter; the white layers are almost wholly free of any colored cement, and of angular or even subangular grains; many of the grains are pitted; wind ripples are frequently found at the top of a white layer, on exposed bedding planes.

2. The brown layers are composed almost wholly of angular and subangular grains of many different sizes, from very small to over 1 mm. in diameter; comparatively few rounded grains are present; the color is due to a coating of iron oxide on most of the grains.

These differently colored layers of sand, having such markedly different characteristics, would seem to point clearly to rather different origins. The factors and forces contributing to their formation can hardly be said to be identical. The material of the white layers suggests rounding, pitting, sorting, and deposition by the wind. The material of the brown layers has evidently been water-worn and water-borne, coming from a comparatively distant region. The occurrence of these different layers with their implied differences in origin and deposition may well suggest something of the history of this region, especially in regard to the extent and frequency of rainfall.

As these rocks contain no fossils, and in their general lithological character point to

deposition by the wind, one may at least tentatively conclude that the climate of this region was rather arid at the time the sands composing these rocks were put in place by the forces of nature. This part of the continent was evidently a portion of the great inland desert which is thought to have existed in Triassic times.

It seems probable that at one season this particular locality was swept by winds carrying a burden of well-worn quartz grains, which was dropped when the force of the wind was checked. When the wind rose again, some of this sand was doubtless moved farther on, but a little remained to add to the accumulating layers beneath. At another season, the surface of this wind-laid sand was covered by a deposit of entirely different material, probably brought from some neighboring zone of alluviation by torrential rains. When the water had flowed on, or evaporated, the red-brown material became exposed to the winds, part of it was doubtless swept away, but some was covered with desert sand which continued to accumulate until the next freshet sent more of the red-brown sediment into the depression in the zone of dunes. That this was approximately the mode of deposition seems likely, when we find the one layer to be characteristically wind-borne, and the other water-borne, when all the accompanying facts are considered, and comparison is made with sand deposits that are being formed at the present time.

The study of this sandstone takes on an added interest if we note further that the frequency of recurrence of the brown or white layers often shows a striking regularity or periodicity. Where we find fairly broad white bands, with very thin brown layers alternating, it would seem that a relatively dry season is indicated. On the other hand, when the brown layers are very numerous and close together, it apparently points to frequent rains, with comparatively little deposition of the white sands by the wind. In the solid rock wall, as observed in the quarries, one can note the more or less regular recurrence of the wider bands of white, and if one could be sure that here a wide white band and one or more narrow brown bands represented the deposit of an arid year, one could determine the time required to produce a given thickness of this rock and also draw some conclusion as to the relative aridity of a given year or a series of years. But one can not at present state, beyond reasonable limits, the amounts of either kind of material that might be deposited in a year, and therefore one may not yet say definitely how long it took for a given stratum to be formed, or whether the aridity indicated by a white band corresponds to one season or to several. It may be interesting to note, however, that the recurrence of groups of brown layers with a

Quarry "A"

White Layer	Thickness of White Layers, in Mm., Bottom to Top								
	Section I.				Section II.				
Fifteenth		*22*							
Fourteenth		2			*14* (top)				
Thirteenth		5			13				
Twelfth		5			12				
Eleventh		17	*15*		8				
Tenth		7	8		9				
Ninth		4	6	*22*	8	*32*			
Eighth		10	8	15	7	25			
Seventh	*15*	8	4	7	8	28	*22*		
Sixth	10	8	11	15	10	20	22	*15*	
Fifth	5	10	3	17	10	15	15	15	
Fourth	5	11	12	7	8	13	20	18	
Third	5	10	16	5	5	20	16	21	6 (top)
Second	10	8	4	6	7	25	18	15	12
First	*15*(*B*)	(*15*)	(*22*)	(*15*)	(*22*)	*25*(*B*)	(*32*)	(*22*)	(*15*)

corresponding decrease in thickness of the white layers is found, on the average, following every tenth or eleventh layer.

This recurrence, as observed at a number of places on the quarry walls, as well as on detached fragments, ranges from the sixth to the fifteenth white layer. For example, at one place (Quarry "*A*," Section I.) the writer measured the thickness of the series of white layers, the thickest layers recurring as follows: seventh, eleventh (from and including the seventh), fifth (or fifteenth from the seventh), eleventh, ninth, fourteenth. At Section II., Quarry "*A*," the thickest white layers recur as follows: ninth, seventh, sixth.

Quarry "B," Section I

White Layer	Thickness of White Layers, in Mm., Bottom to Top										
Fifteenth						*11*					
Fourteenth						3					
Thirteenth						2				*10*	
Twelfth		*15*				9		*11*		4	
Eleventh		5			*15*	5		7		7	
Tenth	*6*	6	*13*		4	5	*14*	9		6	
Ninth	3	3	6		5	6	8	10		5	
Eighth	5	3	4		10	8	10	10		5	
Seventh	4	2	10	*15*	10	5	7	8		7	6 (top)
Sixth	4	2	9	15	10	8	3	6	*20*	7	*13*
Fifth	5	5	10	18	4	4	9	10	6	5	12
Fourth	7	4	6	5	2	15	12	11	5	7	10
Third	6	4	4	10	3	15	10	6	5	6	10
Second	6	5	3	3	5	10	5	7	8	13	8
First	*10*(B)	(*6*)	(*15*)	(*13*)	(*15*)	(*15*)	(*11*)	(*14*)	(*11*)	(*20*)	(*10*)

At another place (Quarry "*B*"), about a quarter of a mile away, the following periods were observed: tenth, twelfth, tenth, seventh, eleventh, fifteenth, tenth, twelfth, sixth, thirteenth, sixth. These three sections are about 2.5, 2 and 4 feet in thickness, respectively. The details of these measurements are shown in the tables above. On about 18 quarried fragments it was found that on the average every eighth to twelfth white layer was thicker than those between. On several such fragments, this recurrence was observed as follows: eleventh; tenth; eleventh and following ninth; eighth; ninth and following eleventh; tenth.

Another striking periodicity may be noticed in the tables. These periods correspond rather well to the average number of years in the Brückner cycle, as from the top of column 1, Section I., Quarry "*A*," to the top of column 4, same section, there are a total of 33 white layers. In the section from Quarry "*B*," from the layer at the top of column 4 to the top of column 7, there are 34 white layers; from the top of column 7 to the top of column 11, there are 34 white layers. Likewise, from the top of column 2 to the top of column 6 there are 40 white layers; from the top of column 6 to the top of column 10 there are 38 white layers.

It may be that it is just by chance that these layers are arranged in this way, yet the agreement with known climatic pulsations is so striking as to make one ask whether it is just chance after all, or a result of natural laws. It is quite evident that the recurrence of layers of a certain character is periodic. Whether one can in this manner safely assign a limit to the yearly deposits seems questionable, but one may certainly inquire into the probability of deducing from a study of these variegated sandstones the conclusion that at the time of their formation the climatic conditions, especially with reference to rainfall, were fluctuating much as they have been within recent times.

It would be distinctly interesting to know whether geologists can find, in more exact and complete studies, further evidence of pulsatory changes of climate having been recorded in the clastic rocks.

C. E. VAIL

COLORADO AGRICULTURAL COLLEGE,
FORT COLLINS

KANSAS CITY MEETING OF THE AMERICAN CHEMICAL SOCIETY

The fifty-fourth meeting of the American Chemical Society was held at Hotel Muehleback, Kansas City, Kansas, from April 10 to April 14, 1917. The general program was carried out under the able leadership of Professor Julius Stieglitz, president of the society, and Dr. Charles L. Parsons, secretary, while the various divisions were presided over by Charles L. Alsberg, E. H. S. Bailey, J. E. Breckinridge, J. R. Bailey, H. E. Howe, H. P. Talbot, L. F. Kebler and T. J. Bryan.

During the session the usual order of business was carried out, consisting of meetings of the council, inspection of plants, with general and public sessions. A complimentary smoker and subscription banquet added to the diversion of the week.

On Wednesday morning, April 11, addresses of welcome were given by Hon. George H. Edwards, mayor of Kansas City, and by Dr. Frank Strong, chancellor of the University of Kansas. Response to these addresses was made by President Julius Stieglitz. Mr. Arthur J. Boynton gave a very interesting paper on the Economic resources of the Kansas City zone.

Wednesday afternoon was given over to a public session, of which the program was as follows:

PETROLEUM AND NATURAL GAS

H. P. Cady, *Chairman*

The geology of the mid-continent oil and gas fields: Raymond C. Moore.

Variations in the composition of gases of the mid-continent field: H. C. Allen and E. E. Lyder.

Helium and associated elements in Kansas natural gases: C. W. Seibel.

Some experiences in the use of oxy-acteylene welding in long distance natural gas transportation: E. P. Fisher.

The cracking of petroleum in the liquid phase: Roy Cross.

One billion gallons of synthetic gasolene in 1918: Walter F. Rittman.

The chemical work of the petroleum division of the Bureau of Mines: Harry H. Hill.

Thursday morning was given over to a symposium on the chemistry and metallurgy of zinc, Professor John Johnson presiding. The remainder of the day and Friday were occupied with the meetings of the divisions.

The following abstracts of papers presented have been prepared by the authors for publication in Science:

DIVISION OF BIOLOGICAL CHEMISTRY

C. L. Alsberg, *Chairman*

I. K. Phelps, *Secretary*

The toxicity of galactose and mannose for green plants and the antagonistic action of other sugars toward these: Lewis Knudson. The toxicity of galactose to the growth of *Pisum arvense* L. and to *Triticum sativum* L. was inhibited by glucose or saccharose, the former being slightly more effective than the latter. But levulose, arabinose, maltose and raffinose do not inhibit the toxicity of galactose, although in presence of levulose the primary root may continue its growth to a limited extent It was found that 0.0125 mol. galactose was as toxic as 0.025 mol, the other sugars being used at a concentration of 0.025. Mannose had a toxic effect similar to galactose. Glucose or saccharose inhibited the toxicity of mannose.

The effect of three annual applications of boron on wheat: F. C. Cook and J. B. Wilson. Borax and colemanite were applied to horse manure in amounts sufficient to act as a fly larvicide. The manure was applied to the same plats at the rate of 20 tons per acre for three consecutive years and wheat was grown on the plats each year at Arlington, Va. A borax, a colemanite, a manured control and an unmanured control plat were used. It is calculated that the upper 6 inches of soil of the borax plat received .0088 per cent. H_3BO_3 the first year and .0022 per cent. the second and third years. The colemanite plat likewise received .0029 per cent. H_3BO_3. Borax reduced the yield of grain 10 per cent. in 1914 and 1915, colemanite had little effect. In 1916 the yields from all four plats were low, but the borax plat gave the largest yield. The only apparent injury to the wheat was the first season on the plat receiving the large amount of borax. There were no evidences of any cumulative action of boron in the soil.

The after-ripening of fruits: F. W. Muncie and W. P. James, Illinois Agricultural Experiment Station, Department of Horticulture. Attempts to preserve peaches by encasing with hard paraffin were unsuccessful, since considerable decomposition resulted after two months, with a marked production of alcohol and an intensely bitter taste. The color, however, remained normal, and the skeleton of the fruit was not broken down. This last condition is similar to that described for other fruits kept in an atmosphere of CO_2 by other workers and is apparently due to an accumulation of carbon dioxide within and about the fruit.

Peaches decomposed rapidly about the spot where an injection of invertase had been made, or in a solution of invertase. Similar experiments are in progress with apples, in an effort to explain the discrepancy between the decrease in sucrose content of apples during ripening found by Bigelow, Gore and Howard and the absence of invertase from the apples studied by Thatcher. Flesh and epidermis of peaches kept in an atmosphere of O_2 for two months became golden yellow, but turned brown quickly on exposure to air. The flesh was soft, contained a little alcohol, and had an insipid taste. Quantitative study of the respiration of apples in an atmosphere of oxygen, showed that the rate is higher under this condition than in an atmosphere of air.

Quantitative determination of carbohydrates in plant tissues: F. W. Muncie and D. T. Englis. If fresh plant tissue is plunged into warm alcohol and after standing two weeks, the alcohol removed by decantation and expression before extraction with hot alcohol, a large percentage of the sugar (96 per cent. in one experiment) is removed and loss of fructose by hot extraction largely avoided. Mercuric nitrate is more satisfactory to use than the acetate and 10 per cent. phosphotungstic acid than the more concentrated solution used by them. Asparagin also is quantitatively removed from solution by mercuric nitrate provided the solution is made just alkaline to litmus with sodium hydroxide or carbonate after addition of the mercuric salt, then just acid with a few drops of weak acid. No mercuric oxide is precipitated by such a procedure. These reagents, especially the phosphotungstic acid, invert sucrose so quickly that they are not applicable to the determination of a mixture of sucrose, glucose and fructose, excepting when sucrose has been previously determined. This may be done by using basic lead acetate as the clearing agent, by the polarimetric method if the inversion is made with invertase or solution again made neutral after use of acid. When the value for sucrose is known, the original solution partially cleared with SO_4-free alumina cream is inverted with invertase, then nitrogenous impurities removed with mercuric nitrate and phosphotungstic acid and total glucose and fructose determined. Subtraction of value for sucrose leaves the values for glucose and fructose present in the original solution.

A physical and chemical study of the kafir kernel: George L. Bidwell. Dwarf, black-hulled, white kafir kernels were separated by hand into bran, germ and endosperm. These parts were analyzed and compared to corresponding parts of corn and were found to resemble them closely. In the bran a wax-like substance was found. The ether extract of the germ was found to be liquid. The endosperm yielded an ether extract not yet examined. The coloring matter in this sample does not seem to be associated with tannin. The endosperm may be separated into starchy and horny parts, the former having less protein than the latter.

Oil from the avocado: H. S. Bailey and L. B. Burnett. The production of the avocado or alligator pear in the United States is increasing so rapidly that there is a possibility of large quantities of this fruit being available as a source of oil. The fruit when fully ripe contains approximately 80 per cent. of moisture and the dried material about 50 per cent. of oil. So far no method has been found by which the oil can be extracted from the fruit in a sweet, edible condition, and as the oil when extracted with ether and the solvent removed at low temperature in vacuum has a bitter taste, it is very doubtful whether the oil as it exists in the fresh fruit itself is palatable if separated from the accompanying pulp. By means of the usual hydrogenation process it is comparatively easy to convert either the expressed oil or that extracted by solvents into a solid, white, tasteless, fat which resembles in its physical properties ordinary hydrogenated cottonseed oil.

Oil from the Stillingia sebefera: H. S. Bailey and L. B. Burnett. The fruit of the semi-tropical tree *Stillingia sebefera*, which grows in China and has been introduced into some of the southern states of this country, produces two glycerides. The exterior of the seed is covered with a wax-like substance from which is derived the Chinese vegetable tallow of commerce. The interior of the seed contains an oil usually known as stillingia oil. Certain statements in the literature indicate that this oil even in China is not used for food purposes and probably has poisonous properties. The constants of these oils have been determined, and experiments made by Dr. William Salant, of the Bureau of Chemistry, in feeding rabbits with both the expressed and extracted oils. So far as the results obtained with the small amount of material available are conclusive, it appears that stillingia oil is not toxic and has practically the same effect as other vegetable oils.

A noteworthy effect of bromides upon the action of malt amylase: Arthur W. Thomas. The action of sodium and potassium bromide upon malt amylase was found to be inhibitory when present

in small amounts, but when these salts were present in greater concentration an activating action was obtained. This action was found when highly purified Lintner soluble starch and thrice repurified bromides were used.

Availability of the energy of food for growth: C. Robert Moulton, Missouri Agricultural Experiment Station. Three beef steers were subjected to digestion trials and maintenance trials. One was slaughtered as a check. The other two were fattened, one to full prime condition and the other to forty or fifty days under prime. All were analyzed. From the analysis the composition of the animals was determined and the composition of the gain. From the feed records and analyses the nutrients consumed above maintenance were determined. The energy equivalent of the flesh gained and of the feed consumed above maintenance was calculated. The two fattened steers saved in flesh gained 53.39 and 52.49 per cent. of the metabolizable energy consumed above maintenance. For similar conditions and a similar ration Armsby shows about 55 per cent. availability. This is an experimental verification of his calorimetric work.

Investigation of the Kjeldahl method for determining nitrogen; the influence of reagents and apparatus on accuracy: I. K. Phelps and H. W. Daudt. As a result of many experiments the conclusion was reached that in all routine work involving determinations by the Kjeldahl method it is necessary to deduct from the result obtained the amount corresponding to the nitrogen contributed by reagents and apparatus in use in the particular experiments. It is obvious that under less carefully controlled conditions in routine work the errors, which are here called inappreciable, will become large enough to seriously effect the accuracy of the results obtained.

A study of the estimation of fat in condensed milk and milk powder: C. H. Biesterfeld and O. L. Evenson. The Roese-Gottlieb method as applied to condensed milk and milk powder gives low results, the average error in the case of condensed milk being 0.04 per cent. The residual fat is obtained by treating the liquid left after three extractions by the Roese-Gottlieb procedure with acetic acid, heating and reextracting with ethyl and petroleum ethers. A method also is described which permits the recovery and repeated use of the solvents.

The Schneyer method for the determination of lactic acid in urine: Mary E. Maver. The Schneyer method for the quantitative determination of lactic acid in urine is not applicable, particularly under pathological conditions. The method is based on the production of CO when the ether extract of urine is treated with H_2SO_4. Hippuric acid is present in the ether extract and does yield CO. Other substances yielding CO, such as oxalic and citric acid, do not enter the ether extract by this method. Citric acid is present in normal urine. The method is of unquestionable value in indicating the excretion of substances under pathological conditions which belong to a group of substances capable of yielding CO under the conditions of the experiment.

On the optimum reaction for tryptic proteolysis: J. H. Long and Mary Hull. It has generally been assumed that tryptic digestion is possible in a neutral or slightly alkaline medium only, but some recent investigations suggest that these limits are too narrow. Employing fibrin as a substrate, the authors have found the optimum point at a hydrogen ion concentration between 10^{-8} and 5×10^{-9}, which is in agreement with the results of Michaelis and Davidsohn for a fibrin peptone substrate. The authors have found, however, that for casein as a substrate the optimum point is distinctly higher, and within the limits 3×10^{-6} and 5×10^{-7}. It is probable that for each type of protein there is a distinct range for the optimum activity and that casein may not be the only protein which is changed readily on the acid side of neutrality. Investigations on other proteins are in progress.

On the normal reaction of the intestinal tract: J. H. Long and Frederick Fenger. Employing the electrometric method of estimation the authors have studied the reaction of the small intestines of a number of animals and also of man. Misled by the false interpretation of the results of indicator tests certain writers have reached wrong conclusions regarding the normal or usual reaction between the pylorus and the lower end of the ileum. In the case of animals the whole intestine has been removed immediately after death, tied into three loops and each loop investigated separately. In some cases the reaction has been found to be acid throughout and from 1 to 3×10^{-7}. Alkaline reaction seems to be less common than acid, and far from the strength once assumed for the duodenum with its alkaline "zone." In the human subject material has been secured from points well below the duodenum by aid of Rehfuss tubes. An acid reaction is frequently noted here and persisting more frequently than the temporary alkalinity following the entrance of bile and the pancreatic fluids

Studies of the gastric residuum. No. III. The relation of total phosphorus to acidity: CHESTER C. FOWLER, Iowa State College. In view of recent support of a modification of Maley's hypothesis concerning gastric hydrochloric acid formation and a suggestion of approximate proportionality which might be expected to occur between the acidity of the juice and its acid calcium phosphate, it seemed desirable to study phosphorus and phosphorus partition of the gastric residuum. Thus fifty-two samples from apparently normal women were obtained and individually analyzed for total phosphorus. The conclusions follow: (1) Total phosphorus was not proportional to total or free acidity. (2) The minimum P_2O_5 content was 6.48 mgr. per 100 c.c. and the maximum was 30.03 mgr. (3) About 58 per cent. of the samples fell within the range P_2O_5 equivalent to 12–18 mgr., while about 21 per cent. lie above and 21 per cent. below these values. (4) A tendency toward a constant P_2O_5 content was shown in individuals who were examined more than once. (5) The average P_2O_5 content was 15.66 mgr. In a previous investigation made upon a composite residuum sample obtained from seventy men, a value of 12.16 mgr of P_2O_5 per 100 c.c. of residuum was obtained.

The utilization of carbohydrate on a relatively high and low cereal diet: ZELMA ZENTMIRE and CHESTER C. FOWLER. The object of the study was to determine any differences in the utilization of cereal protein and carbohydrate in thoroughly cooked cream of wheat when ingested in varying amounts. The data on protein utilization will be presented in a later paper. The experiment was divided into two periods of five days each with relatively high and low amounts of cereal in the diet; and two periods of two days each of nitrogen-free diet of relatively low and high starch content. Casein and milk were added to the cereal diets and butter fat and sucrose to all diets. Foods and feces were weighed and analyzed. The *total* carbohydrate utilization for each of the four periods was over 99 per cent. If the utilization of sucrose and milk sugar is taken as 100 per cent., the utilization of the starch and cereal carbohydrate is about 98 per cent.

The nature of the inosite phosphoric acids of some important feeding materials: J. B. RATHER, Arkansas Agricultural Experiment Station. An inosite phosphoric acid has been separated from wheat bran corresponding in composition to the formula $C_{12}H_{41}O_{42}P_9$, the formula previously proposed for this substance by the writer. It corresponds equally as well to the formula

$$C_6H_6(OH)(H_2PO_4)_5,$$

inosite pentaphosphoric acid. The latter formula, almost exactly one half of the first formula, and that of a theoretically possible compound is adopted as the more desirable. The principal inosite phosphoric acid of a sample of corn was found to be inosite pentaphosphoric acid, and neither inosite hexaphosphoric acid, nor the acid $C_2H_8P_2O_9$. The principal organic phosphoric acid of a sample of kafir corn was found to be inosite pentaphosphoric acid.

The formation of ester hydrolyzing substances by the action of alkali on casein: FLORENCE HULTON FRANKEL. Harriman Research Laboratory, Roosevelt Hospital, New York. The action of alkali on casein causes the formation of ester hydrolyzing substances, the formation of which is practically independent of the concentration of alkali, time of standing and temperature of standing. The substance is more active in very slightly alkaline solution (10^{-8}–10^{-10}) and loses a part of its activity on boiling. It can be entirely removed by long dialyzing. The action was tried on various esters.

Factors influencing the proteolytic activity of papain: EDWARD M. FRANKEL. Papain may be purified by precipitation from aqueous solution with acetone or ethyl alcohol. The ferment is inactivated by acids and alkalis in concentrations from 0.02 normal upwards. The enzyme is active between hydrogen ion concentrations 10^{-2} and 10^{-9}, the optimum being at 10^{-5}, calorimetric standards being used throughout. The quantitative relations of the enzyme and substrate have a marked effect on the extent of proteolysis, increasing quantities of either component causing an increase up to a certain point after which further additions have little effect. In the presence of HCN the proteolytic activity of papain is largely increased the same general relations between enzyme and substrate holding. Increasing the amount of HCN causes increased proteolysis up to a certain point, after which further addition caused no marked change. The same hydrogen ion optimum holds for papain in the presence of HCN as in its absence. HCN will cause further proteolysis in enzyme substrate mixtures that are apparently in equilibrium.

Variations in the chemical composition of alfalfa at different stages of growth: H. S. GRINDLEY and H. C. ECKSTEIN. In connection with investigations which the Illinois Experiment Station is ma-

king to determine the value of forage crops for the growth of farm animals, it became necessary to make complete chemical analyses of young growing grasses and legumes. The first young forage crop to study was that of alfalfa. The work includes the determination of the approximate composition, the forms of non-protein nitrogen, and the forms of protein nitrogen in the grasses and legumes. The results so far obtained with alfalfa lead in general to the following conclusions: First, that young alfalfa is very rich in crude protein; second, that as alfalfa grows older, there is a marked increase in the percentage of nitrogen free extract and crude fiber and a marked decrease in the crude protein of the water-free substance of the plant; third, it seems probable that the marked efficiency of young growing pasture grasses is due (*a*) to their high content of crude protein (*b*) to their high content of mineral constituents and (*c*) to the low content of crude fiber.

Physical and chemical constants of some American tomato seed oils: H. S. Bailey and L. B. Burnett. A number of tomato-seed oils have been made from seeds collected at various tomato pulp factories in Indiana and Maryland and the physical and chemical constants of these oils and their fatty acids determined. One point of particular interest in connection with the tomato-seed oil is that it gives a positive test for peanut oil by the Renard test. If sufficient care, however, is taken in determining the melting point of the final crystalline acids it will be found that they are higher than 72° C., which is usually accepted as the proper temperature for arachidic acid obtained in this method. The analysis of the methyl esters of tomato seed oil and of the saturated fatty acids obtained by the lead-salt-ether method from tomato-seed oil have been made.

A laboratory method for the hydrogenation of oils: L. B. Burnett and H. S. Bailey. A method of preparing a nickel catalyzer, suitable for the hardening of vegetable oils on a small scale in the laboratory, was described.

Electrically heated melting point apparatus: H. S. Bailey. A form of melting point apparatus heated by the passage of an electric current through a bath of dilute sulphuric acid, was described. The resistance of the solution to the passage of the current produces the heat, the increase in which may be regulated by adjustment of the distance between the poles.

The alkaloids of Bocconia frutescens: Emerson R. Miller. In 1895 Battandier examined the bark of *Bocconia frutescens* and reported the presence of fumarine (protopine), bocconine, chelerythrine and traces of an alkaloid giving reactions similar to those of cheliodonine. Bocconine, according to Schlotterbeck, is identical with β-homochelidonine. The writer separated from the leaves of the above-named plant protopine, chelerythrine, β-homochelidonine and γ-homochelidonine. The indications are that the bark contains sanguinarine in addition to the alkaloids reported by Battandier.

On the presence of free hydrocyanic acid in cassava: Emerson R. Miller. Some experiments carried out by the writer while connected with the Cuban Experiment Station show that most of the hydrocyanic acid contained in the roots of *Manihot utilissima* is present, combined as a cyanogenetic glucoside.

The effect of feeding acids upon the growth of swine: A. R. Lamb and John M. Evvard. Although the power to use ammonia produced in the body tissues for the neutralization of acids is known to be possessed by animals, the practical question of the effect of acid-feeding upon growth has not been investigated. Inasmuch as silage contains organic acids in considerable amount and the mineral content of many feeding-stuffs is strongly acid in character, this question is important. Eight pigs, divided into 4 lots, were grown successfully from 85 to 260 pounds weight in seven months upon a normal ration to which considerable amounts of lactic, acetic and sulphuric acids were added.

Can swelling of the colloids furnish a basis for the explanation of edema? A. D. Hirschfelder. Edema due to mustard oil in the conjunctival tissues, the effects of immersing the lid in blood serum, hydrochloric acid, etc., effects of local and general changes in blood pressure upon the development of edema, were discussed.

The following papers were read by title:

The proteins of the peanut, Arachis hypogea. II. The distribution of the basic nitrogen in the globulins arachin and conarchin.

Tissue transplantation as a biochemical method: Leo Loeb.

The alkaloids of Bocconia frutescens: Emerson R. Miller.

Microchemical studies on the mosaic disease of tobacco: G. W. Freiberg.

Some peculiarities of plant decoctions as nutrient media for fungi: R. M. Duggar.

Isolation of parahydroxy-benzoic acid from soil: E. H. Walters.

(*To be continued*)